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Amendments to the Specification:

Please amend the **Specification** as follows:

TITLE OF INVENTION

Applicant

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Citizenship

Indian

Residence

Delhi, INDIA

Title

Two-parallel-wheeled ~~Two-wheel~~ electric motor vehicle ~~where wheels are parallel to each~~ [[other,]] with a provision for connecting ~~two or more such vehicles~~ electromagnetic holonomic wheels in tandem ~~being steered by the front one~~

CROSS-REFERENCE TO RELATED APPLICATIONS

Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

REFERENCE TO A MICROFICHE APPENDIX

Not Applicable

BACKGROUND OF THE INVENTION

~~All the contemporary electrically driven motor vehicles are designs which have been standardized with an internal-combustion machine as the power pack. As the internal-combustion engine runs best at an optimum RPM, and structurally has to be in a cubic form, the need to have gears and a lot other mechanical parts is always there.~~

~~While switching over to an electric-drive principle to run a motor vehicle, the first efforts had been to replace the internal-combustion engine with a high-RPM electric motor. But then there was this need to have a sizeable number of accumulators which, of course, would weigh down the vehicle considerably. It was difficult to create extra space for the accumulators; and changing the batteries in case of emergencies was cumbersome. Additionally, there had been a trend in the recent past to go for small-wheeled vehicles to reduce physical size and to increase manoeuvreability. This tended to increase the rolling friction between the wheels and the road surface, as the ratio between the chord which forms at the road contact and the circumference of the tyre increases with increasingly smaller wheels. It is a major drawback for electric-vehicle design; reducing the range of the vehicle for a full battery charge.~~

The present invention is directed to the field of electrical motor vehicles with zero turning radius. It also relates to those vehicular designs in which the steering of a vehicle is not done by moving the axles of the wheels.

There had been designs in the [[past]] past, which utilized an electric motor inside the wheel. On many [[occasions]] occasions, the wheel is turned into a wheel motor (U.S. Pat. No.5894902). [[motor.]] But as there are no gears in the case of a direct-driven wheel motor, in order to generate a high torque, [[torques,]] either the diameter or the thickness of the wheel motor [[wheels]] has [[have]] to be increased: This makes the [[wheels]] wheel motor heavy. To hold together [[those]] wheels with wheel motors, the axles and the chassis (or the shell) [[all]] both have to be stronger and ~~thus would be~~ heavier than in a vehicle driven by a centrally located ~~centrally located~~ power pack.

How to do away with the numerous mechanical parts which weigh down an electric motor vehicle? [[And]] Moreover, how to reduce the rolling friction to reduce the cruising power requirement of an electric motor vehicle? These were the two major pointers leading to this invention. U.S. Pat. Nos.4163567 and 4192395 disclose vehicles which opened a way to finding suitable answers. The rigid coaxial nature of the two parallel wheels in those vehicles restrict the use of the vehicles to low travelling speeds. Further, the electrical drive motors for the two wheels are located outside the wheel hubs, which limits the number of motors used to drive each wheel without sacrificing useful windscreen width of the vehicles. The bearings of the annular wheels have no provisions to protect against foreign materials from getting into their engaging surfaces. The use of very large wheels does not eliminate other

driving mechanisms outside the wheels, excepting a separate steering mechanism. The rigidity of the mounting of annular wheels on vehicle frame does not take into account, momentary radial impacts on the wheels while rotating as the vehicle travels. These impacts bring about point distortions in the wheel, increasing the friction in the rotation of the wheels.

On factory shop floors, there is a need for simple, low-maintenance traction vehicles of high maneuverability. A two-wheel design improves the negotiability of such a traction vehicle, if necessary features are built into existing art. The most important sought-after feature is to eliminate the need to reverse the vehicle to effect traction. Universal platforms or holonomic wheels are capable of smooth front-rear interchangeability; but they all have more complex tire structures, and have to be necessarily of more than two wheels (U.S. Pat. No.4715460).

The construction of a two-parallel-wheeled vehicle is restricted by the maximum diameter a practical annular wheel can reach without sacrificing structural strength. In order to have more carrying ability or to have more space in a vehicle with no conventional steering or driving mechanism, holonomic wheels are promising. U.S. Pat. Nos.4335899, 4598782, 4715460, 5246238, 5312165 and 6547340 disclose evolving designs in holonomic wheel construction. Excepting U.S. Pat. No.6547340, rest of the designs fail to compensate for the uneven wear of the rollers in the case of rectilinear motion by the vehicle having such wheels. However, in U.S. Pat. No. 6547340, there is no control over the necessary rotation of each roller after it leaves ground contact as the holonomic wheel rotates and the vehicle travels. Further, the scheme of positioning of rollers in a four-wheeled vehicle (U.S. Pat. No.4598782) always generates forces which are not in the direction of actual travel of the vehicle. These forces are also cancelled by the unique positioning. However, not before they have exerted bending stresses on each of the axles of the holonomic wheels. In addition, the workings of the design also depend upon the uniformity of the ground friction each of the wheels experiences. Nonuniform ground friction has to be compensated for by varying wheel rotation in response, as there is no direct control over the rollers on the holonomic wheels of existing art.

BRIEF SUMMARY OF THE INVENTION

This invention ~~fully avoids~~ solves the earlier problems by first increasing the diameter ~~and reducing the number~~ of wheels. In the first version, [[The]] the wheels, two in number, get integrated with the shell of the vehicle, [[doing]] [[away]] dispensing with the solid axle of existing electrical vehicles. ~~The increased diameter of the wheel motor provides more amount of torque at slow speeds without using any gears.~~ The shell of this electric motor vehicle is basically in the form of a modified cylinder with crush zones added on the front and the rear of the vehicle, a portion of the [[circular]] cylindrical side of which faces the surface on which the vehicle travels; both [[the end]] ends of the modified cylinder remain vertical, and these two [[faces]] ends also act as openings with partial or full doors. The two wheels in annular form are mounted [[near]] on the two side faces ends, with the use of toroidal pneumatic flexible mounts. These mounts allow axle formations to deflect in sympathy with radial deflections taking place due to impacting forces acting on the tires; the flexible mounts absorb the deflections, preventing them from distorting the wheels, or the axle formations. ~~The hub of the wheel houses the permanent-magnet rotor, while the circular stator with low-Voltage windings is mounted on the basically~~ The modified cylindrical shell of the vehicle, which vehicle thus acts as the axle formation for both the wheels. ~~In principle, this electric motor vehicle is built inside an enlarged and hollowed out~~ [[axle.]] The electrical energy storage devices are kept near that surface of the shell, the other side of which always faces the ground; [[this]] the positioning of the electrical energy storage devices makes the [[centre]] center of gravity of the vehicle low and lends stability to the design -- this is possible, because all the electrical energy accumulators and superconductor assemblies are heavy. ~~The two wheel motors~~ Numerous lightweight brush-less dc motors housed in biconic rotors circumferentially locate rotatably the inner annular surface [[on]] of both the [[sides]] wheels. Both the wheels [[have]] are driven by individual [[inverter]] switching [[drives]] regulators powering the BLDC motors, also effecting regenerative braking when needed. Steering is accomplished by differential rotation of the [[two giant]] respective wheels. ~~An electrical or wireless link between two or more such vehicles would enable all thus-linked vehicles to travel in tandem, main steering being done by the vehicle on the front; this will simulate the present-day multi-wheel modes of transport, with the ease of detachability and flexibility.~~

Thus, this invention avoids the use of gears, a mechanical steering, suspensions and pneumatic tires; [[tyres;]] it has a much greater torque-generation capability compared to [[other]] motor-wheel designs. The rolling coefficient of friction is low, because the chord-versus-the-wheel-circumference ratio is low due to the increased effective diameter of the wheel. ~~wheel (which is more like a hub). This invention helps to increase the effective travelling range of an electrical vehicle with this structural design philosophy. As the electrical energy accumulators are placed at a level close to the ground, replacing them is easier compared to the existing design of electric motor vehicles.~~

~~With efficiency, simplicity and flexibility, this invention may be the harbinger of the imminent advent of a truly electrical motor vehicle.~~

The second version of the present invention forms a traction vehicular arrangement. In this form, by adjusting the height of the passenger seat to a low it can be turned into a vehicle similar to the version described hereinabove. Otherwise, the traction vehicular arrangement functions in conjunction with wheeled trailers. It is equipped with a hook on the front and the rear. The passenger seat can be rotated vertically to make the occupant of the seat sit facing the opposite side. This effectively makes this a vehicle with an interchangeable front and rear. Both ends of the modified cylinder in this version of the present invention are not used as doors; rather, they are blocked by the annular laminar extension of the hub of the wheels nearly reaching the central axis. This way the entry of foreign material can be blocked completely from entering the bearing and driving mechanisms of the wheels.

The third version of the present invention makes use of holonomic large wheels arranged in tandem with the basic configuration described hereinbefore. Rollers are arranged uniformly on the rim of each holonomic wheel, with their axes perpendicular to the main axis of each holonomic wheel. Each roller has electromagnetic elements to make them function as rotors to an externally placed set of stators of a permanent magnet ac motor or an induction motor. Basic traction and sideways stability of the vehicle is provided by the two large simple wheels which are centrally located side by side. Rest of the tandemly placed holonomic wheels provide horizontal stability to the vehicle; and also provide extra traction by the powered rotation of the individual wheels and steering guidance by the rotation of the rollers with electromagnetic elements powered by the stators which are linked to the chassis of the vehicle, when the rollers are in ground contact. A semi-helix magnetic or electromagnetic element in close proximity of the holonomic wheel tire constituted of the electromagnetic rollers, and fixed to the chassis, imparts a rotatory force on passing electromagnetic rollers to angularly displace them to avoid their getting into ground contact repeatedly at fixed places on their external cylindrical surfaces, even when the vehicle is following a perfectly rectilinear path.

Accordingly, a principle object of the present invention is to simplify the construction of small electric motor vehicle.

It is another object of the invention that the bearing and the electrical drive mechanisms are integrated.

It is a further object of the invention to devise a traction vehicular arrangement with high negotiability and without any mechanical steering whatsoever, to effect remote-control driving of the traction vehicular arrangement.

Another object of the invention is to develop a large-diameter holonomic wheel with powered rollers forming the tire to have active control while steering and to avoid bending forces on the wheel axle generated by the travel of the vehicle on which the holonomic wheel is fixed.

An additional object of the invention is to devise a large vehicle augmenting the reliability of the concept of two parallel wheels put side by side forming a vehicle with an addition of holonomic wheels with powered rollers forming the tire.

The characteristic features of the invention are set forth, in particular, in the appended claims; however, the following description in detail in context to the drawings facilitates a greater understanding of the unique concepts which this invention embodies. But this should be taken as illustrative, rather than restricting the scope of the ideas set forth in the section of Claims. The principles and features of this invention may be utilized in applications outwardly dissimilar but in essence not departing from the scope of this invention.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[[FIG.1]] FIG.1 is a side view of a two-wheel electric motor vehicle in accordance with the first version of the present invention where [[the]] there are just two wheels [[are]] parallel to each other. The wheels are shown resting on level ground, as well as with reference to a plane with [[a 20°]] 20 degrees incline.

[[FIG.2]] FIG.2 is ~~a plan view of the electric motor vehicle in accordance with the present invention, on a 1½-times bigger scale than FIG.1.~~ the leading part of an enlarged cross-sectional view taken along line **20---20** in FIG.1 to show details of the annular wheel of the first version of the present invention.

[[FIG.3]] FIG.3 is a general plan [[front]] view of the first version of the present invention where there are just two

~~two-wheel electric motor vehicle where the~~ wheels [[are]] parallel to each other. ~~other in accordance with the present invention, on the same scale as used in FIG.2. The two wheels are shown resting on level ground.~~

FIG.4 is a general front view of the first version of the present invention where there are just two wheels parallel to each other.

FIG.5 is a general side view of the second version of the present invention with two parallel wheels, to function as a traction vehicle.

FIG.6 is a general front view of the second version of the present invention with two parallel wheels, to function as a traction vehicle.

FIG.7 is an enlarged cross-sectional view taken along line **21---21** in FIG.5, limited to a "dot-dash" circle drawn around line **21---21** and rotated 90 degrees around line **21---21** towards the semi-circular arrow encircling the "dot-dash" circle, to show general details of the bearing and driving mechanisms of the hubs of the two parallel wheels in FIG.5.

FIG.8 is an enlarged cross-sectional view taken along line **22---22** in FIG.5, limited to a "dot-dash" circle drawn around line **22---22** and rotated 90 degrees around line **22---22** towards the semi-circular arrow encircling the "dot-dash" circle, to show details of mounting of the axles of the two parallel wheels on the chassis in FIG.5.

FIG.9 is a schematic side view of the third version of the present invention using electromagnetic holonomic wheels in tandem with two parallel wheels.

FIG.10 is a schematic plan view of the third version of the present invention using electromagnetic holonomic wheels in tandem with two parallel wheels.

FIG.11 is an enlarged cross-sectional view taken along line **23---23** in FIG.**10** of the electromagnetic holonomic wheel with a discontinuous toroidal tire, to show only the details of one roller element with permanent magnets.

FIG.12 is an enlarged cross-sectional view taken along line **24---24** in FIG.**10** to show the general details of a tire of continuous construction.

FIG.13 is an enlarged cross-sectional view taken along line **25---25** in FIG.**10** of the electromagnetic holonomic wheel with a discontinuous toroidal tire, to show only the details of one roller element with squirrel-cage rotor formation.

FIG.14 is an enlarged cross-sectional view taken along line **26---26** in FIG.**9** to show the details of the bearing, driving, steering and braking mechanisms of the electromagnetic holonomic wheel with a discontinuous toroidal tire constituted of rollers with squirrel-cage rotor formations.

FIG.15 is a plan view of FIG.**14** to show some details of steering, braking and stator positioning mechanism

FIG.16 is a schematic pictorial partial view of the electromagnetic holonomic wheel of the present invention along with two integral radially cut-away views across the rim of the wheel to show some details of the axial mount of an individual roller and some cross-sectional details of the inside of one roller element with permanent magnets forming a rotor along with a dual stator formation.

DETAILED DESCRIPTION OF THE INVENTION

~~FIG.1 shows the side view of the vehicle.~~ The first version of the present invention is described in detail with the aid of FIG.1 through FIG.4. The total height of the vehicle in FIG.1 is nearly [[50 inches.]] 1370 mm. In this present form, it is designed to ~~accomodated~~ accommodate two persons with some luggage space at the back. The seats are marked [[S]] 65 in FIG.1, FIG.3 and FIG.4. The batteries Batteries 50 in FIG.1 are placed below [[the]] seats 65. ~~in the area marked BAT.~~ There is a provision to keep [[4 Nos.]] eight numbers of ordinary 200 100AH, 12V ~~12V. Lead acid~~ lead acid batteries. The total weight of the batteries is approximately 240 [[kgs.]] kg. The [[position]] positioning of ~~the battery enclosure~~ batteries 50 keeps the [[centre]] center of gravity of the vehicle very low; this, coupled with the eccentric loading on the vehicle, provides stability to the vehicle, in spite of its having only two parallel wheels. ~~The batteries could be placed in two arrangements. One is side by side, so that the batteries could be taken out from the direction labelled BP in FIG.1. The Battery Protector, BP, is made of material having good impact strength capable of withstanding shock from the rear. A hinged joint at the axis marked HN (FIG.1), allows BP to swivel down and rest on the ground on its edge. Thus facilitating the removal or insertion of the batteries from the rear. The batteries could also be arranged in a transverse manner, as shown in FIG.2. In this case, the batteries have to be accessed from the side doors on both the sides of the vehicle. As the batteries, in this arrangement, are placed in the cavity behind the direct-drive motor M (FIG.1), the circular rim of the motor obstructing the bottom sideways edge of the battery, it is not possible to simply slide the batteries out one by one.~~ ~~The backrests have to fold down on the seats, while the seats having an arrangement to get lifted slightly to make sufficient clearance for the batteries; then a pneumatically-operated robber bag placed below the batteries as a collapsed cushion is inflated to get the batteries lifted enough to be able to slide them out. This arrangement is slightly more complicated than the earlier-described battery-removal procedure; but it makes the vehicle shell stronger by integrating BP with the shell, thus reducing the number of joints in the vehicle.~~[[shell.]] The top and front sides of the battery enclosure have to be strong and fully linked with the structure of the [[shell and,]] shell and, at the extremities, with the ~~direct-drive rim motors:~~ axle formations: So that, in case of an accidental collision, the batteries 50 do not damage the legs of the occupants of [[the]] seats 65 (FIG.1, FIG.3 and FIG.4). The linking of the two ends of [[the]] vehicle shell 64 with the body [[element]] elements 66 and battery enclosure elements 67 and 68 (FIG.1 and FIG.4) ~~of the battery enclosure also~~ increases the overall strength of the vehicle shell 64 (FIG.1 and FIG.4).

~~The back rests~~ Backrest 58 (FIG.1, FIG.3 and FIG.4) of ~~the seats could~~ seats 65 can be adjusted angularly around reclining axis center 49 [[somewhat]] to obtain different reclining angles. In [[FIG.1,]] FIG.1, FIG.3 and FIG.4, the areas marked [[B]] 52 on the front and rear both indicate ~~the light-weight~~ lightweight plastic bumpers. ~~They have an elevated face (FIG.2) marked EL to offer a limited length of their full face in~~ In case of a collision, to

avoid the shock getting transferred on to the wheels and distorting them and to protect the passengers, plastic bumpers 52 and ridged crush-zone elements 53 (FIG.1, FIG.3 and FIG.4) absorb most of the kinetic energy of the impact by collapsing. ~~Though, the ridged sheet-metal rims of the wheels (FIG.2) offer a degree of flexibility and resilience necessary to withstand the rough rides.~~ The [[tyres]] tires are [[huge]] large in diameter (nearly ~~50 inches~~ 1575 mm), but are ~~very thin~~ narrow (~~just an inch~~ 65 mm). ~~This reduces the rolling friction; avoids the use of any kind of suspension or shock absorbers; and opens the possibility of using a solid low-cost rubber tyre (FIG.3; TYRE).~~

[[The doors]] Doors 59 (FIG.1) on both the sides of the vehicle ~~hinge at the axis near the back rest of the seats (AA in FIG.1); the height of the doors is nearly 3 feet.~~ are hinged underneath points 69 (FIG.1) to wheel casing 99 (FIG.2) on surface 101 (FIG.2). The possible sliding glass portions of the window is marked [[WN]] 51 in [[1FIG.1.]] FIG.1. ~~The small area on the right-hand side of the vertical cord AA (FIG.1) is immovable and is fixed to the vehicle shell.~~

~~The windscreen~~ Windscreens 110 (FIG.1, FIG.3 and FIG.4) are glued to vehicle shell 64 (FIG.1 and FIG.4). ~~vertically, in a circular fashion, spans points WW (FIG.1). The head~~ Head lamps 112 (FIG.3 and FIG.4) are placed ~~in the niche HL (FIG.1) – shown more clearly in~~ [[FIG.3.]] just above ridged crush-zone elements 53. In order to conserve power, use is made of 2 Nos. of 20W fluorescent tubes for head lamps 112 (FIG.3 and FIG.4) driven by high frequency drivers. The right and left turn indicators are marked [[T.I.L.]] 113 in [[FIG.3.]] FIG.3 and FIG.4. The two fluorescent tubes with suitable cylindrical reflectors produce high and low beams; [[the]] [[Fresnel]] lenses in the path of light help to further focus the light beam.

~~On the rear side end of the vehicle, there is a boot space; the boot hatch door may open at point marked BH in FIG.1. There are two locations for keeping the various electronic controllers. One is the rear side of the seat back rests; the other is the place marked E in FIG.1. The traction, steering, braking and communication with the virtually-linked similar vehicles in tandem: All are accomplished using this controller and drives.~~ There are two separate [[drives]] switching regulators for each multitude of brush-less dc motors rotatably locating respective annular wheel drums 75 (FIG.2) by engaging with two parallel O rings 76 (FIG.2). ~~the two permanent-magnet AC motors working as direct-driving rim~~ [[motors.]] Rotor 94 (FIG.2) is of truncated biconic form. Stator 96 (FIG.2) is fixed in the toroidally formed channel 85, as shown in FIG.2. Toroidally formed channel 85 is secured to vehicle shell 64 (FIG.1 and FIG.4) with the use of toroidal cushion 86 with pneumatic cavity 88 and steel cords 87 (all in FIG.2). Toroidal cushion 86 is made of elastomeric material and grips double-flanged member 89 (FIG.2). Double-flanged member 89 on its internal flanged flat side is bolted (90 in FIG.2) to wheel casing 99; while from the outside, wheel protector baffle 62 is screwed on to it by screws 98 (FIG. 2). Wheel protector baffle 62 (FIG.1, FIG.2, FIG.3 and

FIG.4) is injection molded with a thermoplastic. Elements **60** and **61** (FIG.1) also are modified wheel protector baffles doubling up as side bumpers. Similarly, element **48** (FIG.1) is an injection-molded bumper to protect door **59** (FIG.1). Electrical conductors to each BLDC motor enter stator **96** sideways from slot **93** to travel through coaxial tubular cavity **91** to reach stator windings **83**, via radial holes **92**, after switched by electronics placed in cavity **100**. Multi-pole ring magnet **82** is made of rare earth elements. Each BLDC motor has two numbers of double-Z ball bearings **95** (all in FIG.2). Annular wheel **57** has a solid rubber tire **56** (FIG.1, FIG.2, FIG.3 and FIG.4) secured on rim **73** (FIG.2). Solid rubber tire **56** has a grooved tread **70**, nylon fiber ply **71** and steel cords **72** (FIG.2). Annular wheel **57** is fixed by multiple studs **103** and nuts **77** (FIG.2). Ring **104** (FIG.2) secures O ring stopper **78** and dust protector **79** on the other side of the side annular wheel **57** is fixed on annular wheel drum **75** (FIG.2). By altering the [[RPM]] rpm of individual [[motors,]] wheels, steering of the vehicle is achieved. ~~By stopping one motor entirely, the moving wheel of the vehicle draws a circle on the ground, the centre of which is the point where the non-rotating wheel rests on the ground; this capability makes the turning radius very small, equal to the distance between the centres of the two tyres on the either side.~~ Dynamic regenerative braking is also effected by the two [[drives;]] switching regulators and is very effective, owing to the [[huge]] large diameter of the [[motor.]] annular wheel **57** (FIG.1). ~~The stator is wound for 24V. DC, and is epoxy encapsulated. The rotor consists of small ferrite magnets arranged on the rotating rim. The bearing of the motor is on the walls of the wine-glass-like shape, to where the arrow marked M points in FIG.2.~~ At the parting lines of ~~the rotor and the stator,~~ annular wheel drum **75** and toroidally formed channel **85** (FIG.2), to protect the bearing and driving mechanisms from dirt, there are thin annular rubber curtains **80** and **81** (FIG.2), against which there is an optional positive air pressure from the inside of [[the stator]] toroidally formed channel **85** -- worked up by [[a]] small centrifugal fan [[pump]] pumps which [[sucks]] suck filtered air from the inside of the vehicle and [[pushes]] push it out through the leakage between the line of contact between [[the]] annular rubber [[curtain]] curtains **80, 81** and ~~the hub and the axle~~ annular wheel drum **75** and toroidally formed channel **85**, to prevent the entry of dust, dirt and water at low pressure heads.

In the case of the failure of the switching devices of one or both the [[drives,]] switching regulators, there is a provision for two parallel stopping drives which otherwise work as regenerative brakes to first charge two capacitors from the ~~regenerative~~ regenerated braking power and then to step up the capacitor ~~voltage with a~~ voltages using switching [[convertor]] converters, and then to charge [[the]] batteries **50** (FIG.1). To act as parking brakes, [[on]] ~~points marked as (FIG.1) PBR,~~ there are [[two]] four small [[DC]] dc motors with integral gears driving [[two]] four threaded shafts which in turn move threaded ~~sliding blocks~~ sliders lined ~~on their heads~~ with braking material. Application of this braking arrangement involves the rotation of the geared [[DC]] dc motors in [[the]] positive direction in order to move the [[braking]] sliders towards the ~~rotor's magnetic~~ [[face.]] internal cylindrical surface of annular wheel drum **75** (FIG.2) lying between the seats of two O rings **76** (FIG.2). When the brake linings press against the [[rotor]] wheel drum face, due to the enormous diameter of [[the rotor,]] annular wheel drum **75**, the

braking effectiveness is [[very]] good. In order to release this parking brake, the direction of motor [[rotation]] rotations is reversed by reversing the connection of the small [[DC]] dc motors electrically. This braking is ~~indispensable while~~ very useful for ~~parking, as their are no gears in this vehicle and~~ parking; injecting a [[DC]] dc voltage in all the [[rotor]] brush-less dc motor windings to achieve electromagnetic braking would drain the [[battery,]] batteries, and short-circuiting of BLDC motor windings only effects dynamic braking.

Steering, speed and braking are manually controlled by operating a wired or cordless [[joystick;]] manipulator; the driver may sit at any location in the vehicle. Ground clearance even on an ~~inclined surface~~ incline of 20 degrees is adequately demonstrated with reference to ~~the line marked INCL.~~ surface 54 in [[FIG.1.]] FIG.1 in comparison to level ground 55 (FIG.1 and FIG.4). ~~It is also noticeably clear in FIG.3, just above the road surface marked R.~~

~~The number of batteries could be made just two, to make the vehicle lighter and go faster, with travelling distance getting halved.~~ By making the driver sit in a more crouched manner, the diameter as well as the breadth of the vehicle could be reduced to produce a [[midget-size]] small vehicle, unlike the conventional bikes: A stable vehicle suitable for single occupancy, protecting the occupant from the vagaries of [[the]] weather.

~~Dynamic towing is achieved by attaching one or more similar vehicles behind or along the sides of the pilot vehicle. An electronic communication link permits the driver of the driver of the pilot vehicle to safely steer this train of identical vehicles; thus effecting the concept of splitting a conventional four-wheel vehicle, or joining up, as and when required. The vehicles following the pilot vehicle have a user-defined degree of manoeuvreability. The addition of a towing link on the backside of this electric vehicle will enable it to work as a traction vehicle inside factories. Unlike conventional three-wheeled electrical traction vehicles, the driver sits inside a well-defined and protected space, though the overall size of the vehicle is smaller compared to its existing counterparts.~~

The peculiarities of this electric vehicle design make it very stable in dynamic performance. While applying brakes, [[the]] vehicle shell 64 (FIG.1 and FIG.4) tends to rotate with the wheels, but the heavy battery compartment keeps moving forward, thus [[cancelling]] canceling [[out]] the likely swing of [[the]] vehicle shell 64 backwards. ~~anti-clockwise. The position of the occupants of the vehicle always remains gravitationally the same, reducing, possibly, stress while travelling over inclines, (marked INCL in FIG.1).~~

The batteries, even if replaced by fuel cells or superconductor assemblies, always have one common feature -- weight. The weight of the electrical energy storage or generating units could not possibly be reduced in near future. ~~And in this design this~~ In this first version of the present invention, concentration of weight lends itself remarkably well to the effective functioning of this electric motor vehicle.

~~To improve the dimensional stability of the shell, ridges are formed on the sheet-metal shell just at place where the shell forms a neck to accomodate the wheel motor, shown in FIG.2 and FIG.3 (RIDGES).~~

~~In a midget-sized single-seater version of the present vehicle, back rest is in a foldable form; two such back rests linked to both the sitting edges of the driver seat~~ Backrest **58** and head rests **63** (FIG.1, FIG.2 and FIG.4) are padded equally on both front and rear sides, [[make]] making it possible to sit inside the vehicle facing any of the two ends -- conventional front or rear -- and drive, as there are no mechanical linkages for driving this vehicle; and the ~~joystick controller~~ manipulator could be operated [[in]] from any [[position.]] location. Additionally, with backrest remaining vertical, passengers can occupy the whole of seats **65**, accommodating two more passengers as a result.

The second version of the present invention is described in detail with the aid of FIG.5 through FIG.8. The outer diameter of traction tire **121** (FIG.5 and FIG.6) is nearly 1370 mm. Traction tire **121** is non-pneumatic and is fixed on traction wheel **132** (FIG.5 and FIG.7). Traction wheel **132** is bolted to traction wheel drum **141** (FIG.7) in the manner described hereinbefore and shown in FIG.7. The bearing and driving mechanisms are common, and are shown in FIG.7. They are essentially the same as described earlier and are shown in detail in FIG.2. There are only three modifications: **(a)** two numbers of BLDC motors are axially adjacent at one circumferential location, **(b)** toroidally formed channel **85** of FIG.2 is replaced by floating ring **131** and axle ring **139** (FIG.7); and **(c)** dust protector **79** in FIG.2 is modified (element **140** in FIG.7 and FIG.8)) to radially extend near axle locator **127** (FIG.6 and FIG.8) at the center of traction wheel **132**. Element **140** seals the internals of wheel bearing and driving mechanisms in conjunction with O rings **129** and **137** (FIG.8). Four numbers of clamping bolts **138** (FIG.8) secure axle locator **127** (FIG.6 and FIG.8) to chassis **143** (FIG.5, FIG.6 and FIG.8). Dust protector baffle **142** (FIG.7 and FIG.8) is structurally similar to element **140** (FIG 7 and FIG.8) on its circumference, and is clamped underneath traction wheel **132** (FIG.7) to traction wheel drum **141** (FIG.7); dust protector baffle **142** remains centrally at a distance from axle locator **127** (FIG.8). Semi-circular profiled O ring **130** is located in a groove medially on the inner annular surface of traction wheel drum **141** (FIG.7). Semi-circular profiled O ring **130** (FIG.7) functions as two numbers of O rings **76** (FIG.2) as shown in FIG.7. External wheel casing **125** (FIG.5, FIG.6 and FIG.7) is immovably joined to chassis **143** (FIG.6 and FIG.8).

Batteries **50** (FIG.5) are similar to the ones employed in the first version of the present invention. Batteries **50** are eight in number and are arranged in a single row on the base of chassis **143** (FIG.5 and FIG.6). The row of batteries **50** is protected by protective bumpers **122** (FIG.5 and FIG.6) which are made of metal or thermoplastic. The front and rear of the vehicle are identical in appearance. Both front and rear of the vehicle have a hook **120** with a locking link **123** held by a pin **124** (all in FIG.5 and FIG.6). Driver seat **133** (FIG.5 and FIG.6) is optional, as the

vehicle can be driven by a remote control or programmed to follow fixed paths. In the absence of driver seat **133** the space above batteries **50** (FIG.5) can be used for carrying goods. Positioning channels **134** (FIG.5 and FIG.6) serve to lift and lower driver seat **133** which gets located from rocking axis ends **135** (FIG.5 and FIG.6). Rocking axis ends **135** also locate driver seat **133** when it is tilted suitably to interchange the backrest with the sitting space, to make the driver sit facing the other end of the vehicle. Lowering of driver seat **133**, enables the vehicle to travel as a vehicle which is functionally similar to the first version of the present invention.

The third version of the present invention is detailed with the aid of FIG.9 through FIG.16. In FIG.9, a vehicle is resting on level ground **55**. Vehicle chassis **154** has six numbers of wheels of different diameters. Four of the wheels on the left side in FIG.9 and FIG.10 have their axes marked **151**, **152**, **153**.and **153**. Simple wheels **157** (FIG.9 and FIG.10) seem to have a common axis **153** in FIG.10 which perpendicularly bisects longitudinal mesial line **150** in FIG.10. Longitudinal mesial line **150** (FIG.10) is an imaginary line drawn in FIG.10 to indicate the locations of simple wheels **157** and electromagnetic holonomic wheels **155** (FIG.9 and FIG.10). If the length of this vehicle is extended by adding more wheels on both sides of axis **153** as marked in FIG.10, the additional wheels have to be electromagnetic holonomic wheels **155**. Electromagnetic stator unit **201** (FIG.9, FIG.10, FIG.14, FIG.15 and FIG.16) generates a moving electromagnetic field which magnetically forces the rollers on electromagnetic holonomic wheel **155** to rotate or stall, depending upon the direction or nature of the electromagnetic field generated by electromagnetic stator unit **201**.

The vehicle as depicted in FIG.9 and FIG.10 utilizes two parallel simple wheels **157** for main traction, steering, braking and sideways stability while travelling. Basic operation of two parallel simple wheels **157** (FIG.9 and FIG.10) is similar to the description of the operation of the first and second version of the present invention hereinbefore; however, the bearing and driving mechanisms can be different. Continuous construction of the solid tire of simple wheel **157** in FIG.9 and FIG.10 is shown in FIG.12 in detail. Grooves **167** on tread **179** ensure road contact in wet conditions (FIG.12) and ply **165** forms the skeleton of the tire (FIG.12). Wheel **163** (FIG.11, FIG.12, FIG.14 and FIG.16) is of general construction. Rim **73** in FIG.12 is generally similar to as detailed in FIG.2. The base width and shape of rim **73** in FIG.12 depends upon the thickness and construction of tire selected for simple wheel **157** (FIG.9 and FIG.10).

The rollers on electromagnetic holonomic wheel of the present invention are internally of two possible type **(a)** magnetic and **(b)** electromagnetic. FIG.11 shows the details of a multi-pole magnetic roller. Permanent magnet pole pieces **156** (FIG.11) are fixed uniformly on the outer cylindrical side of an Archimedean spiral composed of a spring steel strip **177** (FIG.11), which starts and ends shaped as small and large concentric right circular cylinders. The magnetic poles of identical permanent magnet pole pieces **156** (FIG.11) alternate in direction with their alternate

poles radially directed outwards. The Archimedean spiral composed of spring steel strip **177** (FIG.11) has a variable lead which increases in the middle of the curve and becomes zero at the points of termination (shown in FIG.11 and FIG.16). The Archimedean spiral composed of spring steel strip, with permanent magnet pole pieces **156** fixed as described, is molded with an elastomeric medium **158** (FIG.11); this whole unit in turn is fixed on a nylon bushing **159**, and a rubber tread ring **178** (FIG.10 and FIG.11) cylindrically covers a part of the external surface of this whole unit to form a magnetic roller ready to come into contact with level ground **55** (FIG.9) after axle pin **160** (FIG.11 and FIG.16) is passed through nylon bushing **159** (FIG.11) and axle pin **160** is fixed from both ends to brackets **175** (FIG.11). Brackets **175** (FIG.11 and FIG.16) are equal in number to the number of magnetic rollers on electromagnetic holonomic wheel **155** (FIG.10). Brackets **175** (FIG.11) are uniformly joined to rim **162** (FIG.11, FIG.13, FIG.14 and FIG.16) to rotatably hold all the magnetic rollers from their axle pins **160** (FIG.11 and FIG.16). Axle pins **160** have sealing grooves which position sealing rings **161** (FIG.11), in order to prevent foreign material from getting into the bearing formed by axle pin **160** and nylon bushing **159** (shown in FIG.11). Every electromagnetic holonomic wheel of the present invention which employs axle pins **160** to rotatably hold electromagnetic rollers of either kind, has to have one axle pin **160** of slightly modified construction which has a transverse threaded joint in the middle. This joint makes the modified axle pin manually adjustable in length. This helps in the final fixing of all axle pins **160** (FIG.11 and FIG.16) together with the electromagnetic rollers on rim **162** (FIG.11 and FIG.16).

Electromagnetic rollers on the electromagnetic holonomic wheel of the present invention are best described with the aid of FIG.13 and FIG.14. In FIG.13, silicon steel stampings form squirrel-cage rotor stack **171** on the cylindrical exterior of which are fixed aluminum squirrel-cage conductors **170** in angular uniformity. Fiber ply **174** (FIG.13 and FIG.14) is spirally interspersed in elastomeric medium **158** (FIG.11, FIG.13, FIG.14 and FIG.16). Elastomeric medium **158** cylindrically holds on the outside the assembly of squirrel-cage rotor stack **171** and aluminum squirrel-cage conductors **170**, and internally grips nylon bushing **159** which is rotatably positioned by axle ring **172** (all best viewed in FIG.13). Rubber tread ring (FIG.13 and FIG.11, as well as in FIG.14 and FIG.16) fits on the external cylindrical surface of squirrel-cage rotor stack **171**. Spacer brackets **176** (FIG.13 and FIG.14) are similar to brackets **175** (FIG.11 and FIG.16), except for the fact that spacer brackets **176** are shorter in height compared to brackets **175** with the top half of the hole in brackets open to receive axle ring **172** which is almost full circle with just a missing part; this missing part is a small lock nut (not shown) which holds both ends of axle ring **172** together. The roller electromagnetic meant to be positioned after tightening of the lock nut is made of two identical halves (not shown) which are screwed on to each other after positioned appropriately around the lock-nut part of axle ring **172** (FIG.13). In FIG.13 two circular grooves (not shown) can be cut on either ends in the bore of nylon bushing **159** to accommodate two rubber seals accomplishing the function of sealing rings **161** (FIG.11).

Electromagnetic stator units **201** (FIG.9, FIG.10, FIG.14, FIG.15 and FIG.16) are essential for effective operation of the electromagnetic holonomic wheel of the present invention. The placement and orientation of electromagnetic stator unit **201** is shown in FIG.16, while one possible version of the placement of electromagnetic stator unit **201** is shown in FIG.14. and FIG.15. Stator windings **200** (FIG.14 and FIG.16) are basically similar, in spite their being wound for different kind of electric motors; it is an induction motor in FIG.14, while in FIG.16, it is a permanent magnet ac motor. For having a higher number of poles with higher torque generation ability it is necessary that the magnetic circuit between the left-hand side and right-hand side stator units **201** is joined using ferromagnetic members outside of the rotor elements inside the rollers of the electromagnetic holonomic wheel of the present invention. This joining is done at semi-circular lock **211** (FIG.14) involving silicon steel stampings stacked together forming stator link **218** (FIG.14) and one electromagnetic stator unit **201** on either side of holonomic wheel drum **202** (FIG.14).

Semi-circular lock **211** (FIG.14) allows a little angular freedom in reference to the geometrical center of concentric semi-circles of semi-circular lock **211**. This angular freedom is essential for top cam disc **207** (FIG.14 and FIG.15) and bottom cam disc **208** (FIG.14) to rotate appropriately urged by planetary gears **212** (FIG.15) driven by geared dc motor **206** (FIG.14) through pinion **216** (FIG.15). Geared dc motor **206** (FIG.14) fits through a cylindrical shaft formed by common punchings in stator link **218** (FIG.14) and corresponding openings in toroidally formed channel **209** and insulating spacer **210** (FIG.14). Top cam disc **207** and bottom cam disc **208** to the naked eye look like perfectly circular discs; their diametrical deviations at different points of their circumference is less than a millimeter. They are assembled with reference to each other; and by their joint predetermined amount of rotation governed by an encoder built into geared dc motor **206** (FIG.14), the physical proximity of both electromagnetic stator units **201** to rubber tread rings **178** (FIG.14 and FIG.16) is controlled in order to effect electromagnetic and mechanical braking of the electromagnetic rollers and electromagnetic holonomic wheel **155**, and also to optimize the magnetizing current through stator windings **200** (FIG.14 and FIG.16): In rough driving conditions the physical proximity is decreased to avoid any possible mechanical friction between electromagnetic stator units **201** and rubber tread rings **178**; conversely, on smooth roads the physical proximity has to increase in order to increase control over electromagnetic rollers to avoid veering off of the vehicle of the present invention due to insufficient surface friction and steering control. Wheel **163** (FIG.14) is of general construction and described with reference to FIG.2 and FIG.7 hereinbefore. Holonomic wheel drum **202** (FIG.14) is made of aluminum alloy to keep it light in weight. Bolts **203** locate wheel **163** (FIG.14). Two each of O rings **204** and **205** are respectively similar to O rings **130** (FIG.7) and **76** (FIG.2) except for dimensional variations. The bearing and driving mechanisms are also similar to the ones shown in FIG.2 and FIG.7, except for an increase in the number BLDC motors in one axial row by one. Toroidally formed channel **209** (FIG.14) is also similar to toroidally formed channel **85** (FIG.2) except for an extra axial inverted V-shaped cavity to accommodate the extra BLDC motor just described.

Insulating spacer **210** (FIG.**14**) is employed to stop wasteful eddy current generation into toroidally formed channel **209** (FIG.**14**). Cover plate **214** (FIG.**14**) is screwed on with screws **215** (FIG.**14** and FIG.**15**) to vehicle chassis **154** (FIG.**9**, FIG.**10** and FIG.**14**) on the opening above top cam disc **207** (FIG.**14** and FIG.**15**)

In FIG.**16**, twisted magnetic strip **230** is connected to vehicle chassis **154** (FIG.**9** and FIG.**10**) and has both magnetic poles **231** and **232** (FIG.**16**) all through uniformly facing rubber tread rings **178** (FIG.**16**) on all the magnetic rollers in FIG.**16**. As wheel **163** (FIG.**16**) rotates around wheel axis, adjacent magnetic rollers line up in an orderly manner as opposing magnetic poles located in adjacent magnetic rollers pull close. When no steering taking place and the vehicle travelling in a straight line on level ground **55** (FIG.**9** and FIG.**10**), the magnetic rollers in FIG.**16** do not rotate around their respective axis (two such axes are shown as axle pins **160** in FIG.**16**); in this condition the magnetic field produced by twisted magnetic strip **230** (FIG.**16**) imparts a rotating magnetic field on permanent magnetic pole pieces **156** (FIG.**11** and FIG.**16**), which urges the magnetic rollers to displace angularly around their respective axes, axle pins **160**. The electromagnetic rollers depicted in FIG.**13** and FIG.**14** will also displace in the same manner when subject to the rotating magnetic field just described.

Magnetic or electromagnetic sensors are fixed in line but at a distance from the symmetrical ends (one of the ends showing stator windings **200** in FIG.**14** and FIG.**16**) of electromagnetic stator units **201** (FIG.**14** and FIG.**16**). The sensors pick up signals from rotating rollers after they leave ground contact with the rotation of wheel **163** (FIG.**14** and FIG.**16**) as the vehicle travels on level ground **55** (FIG.**14**). These signals are useful in efficient steering control. In many travelling conditions, active rotation of the rollers by powering electromagnetic stator units **201** is not needed; just by differential rotation of two simple wheels **157** (FIG.**9** and FIG.**10**) adequate steering is achieved. In those conditions signals from the sensors just described are sampled and if found adequate, no power is supplied to electromagnetic stator units **201**. The sensors also sense insufficient rotation of the rollers, and for a short duration the power to electromagnetic stator units **201** is increased.

An increase in the number of electromagnetic stator units **201** (FIG.**14** and FIG.**16**) symmetrically on both sides of wheel **163** (FIG.**14** and FIG.**16**) replicating the arrangement of electromagnetic stator units **201** in FIG.**16** in a circular row not only increases steering power to some extent; but it also helps in urging the main rotation of wheel **163** (FIG.**14** and FIG.**16**) around its main axis, as different row-wise placed electromagnetic stator units **201** are sequentially powered, producing a circulating magnetic field in sympathy with the main rotation of wheel **163** (FIG.**14** and FIG.**16**). Extra electromagnetic braking force is also developed using this arrangement.

Extra magnetic or electromagnetic sensors are fixed to vehicle chassis **154** (FIG.**9**, FIG.**10** and FIG.**14**), close to the rollers of electromagnetic holonomic wheel of the present invention. These sensors pick up signal corresponding

to the main rotation of wheel **163** as well as the rotation of rollers on wheel **163** (FIG.9, FIG.10, FIG.14 and FIG.16). These sensors are of importance because they confirm the main rotation of wheel **163** in addition to the sensors described earlier, and they also sense the necessary constant angular displacement of the rollers on wheel **163** under the magnetic influence of twisted magnetic strip **230** (FIG.16) and/or electromagnetic stator units **201** (FIG.14 and FIG.16).

The rollers in FIG.11 can be made lighter by using multi-pole plastic-magnet rings instead of permanent magnet pole pieces **156**. Only rubber tread rings need be replaced after wear. The rollers in FIG.13 can be designed to function without rubber tread rings **178**. For this purpose, aluminum squirrel-cage conductors **170** have to be of hardened aluminum alloy, and squirrel-cage rotor stack **171** has to be made of hard silicon-steel stampings (FIG.13 and FIG.14). Special purpose vehicles can be made using such rollers.